How (and why) should we map corticospinal tract projection patterns in unilateral CP? Commentary on Kuo et al. (Using Diffusion Tensor Imaging to Identify Corticospinal Tract Projection Patterns in Children with Unilateral Spastic Cerebral Palsy)

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Word count 650

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In this issue, Kuo et al.[1] investigate whether diffusion tensor imaging (DTI) can be used to identify preserved corticospinal tract projections from the affected motor cortex in children with unilateral cerebral palsy (UCP). Children in whom this projection is partly preserved have in general better hand function than those with a predominant ipsilateral corticospinal tract projection from the unaffected motor cortex.

Traditionally, descending motor pathways have been investigated non-invasively in man using transcranial magnetic stimulation (TMS). This method provides a functional assessment of corticospinal tract connectivity, by measuring the motor evoked response in muscle in response to a brief magnetic pulse from a coil held over the motor cortex. TMS is not always well tolerated though, and some children are considered ineligible because of an active seizure disorder. An alternative non-invasive structural imaging-based method would be valuable; however, non-invasive assessment of the corticospinal tract is not as easy as it sounds. Identification of the corticospinal tract with DTI is a complex reconstruction process involving a mixture of combining neuroanatomical prerequisites with tracking of "fibres" based on adjacent voxels with properties consistent with a single, coherently oriented bundle of axons with high fractional anisotropy. Areas where fibres cross are difficult to track; errors could lead to "tracking" pathways which do not exist. In contrast to TMS which assesses the whole motor pathway from cortex to muscle, DTI only provides information as far as the brainstem. In children with severe UCP, it may be challenging to reconstruct a highly disorganised tract with DTI, leading to false negative results.

TMS over the motor cortex does not exclusively stimulate the corticospinal tract - other pathways such as the bilaterally projecting reticulospinal tract can also be activated - but early latency motor evoked potentials predominantly reflect the fastest-conducting corticospinal tract fibres. Some participants with unilateral cerebral palsy may have high thresholds for activation of the affected corticospinal tract, potentially giving false negative results. Also, as the response to TMS is measured using surface electromyography over target muscles, altered peripheral nerve conduction times are a theoretical confounder.

Before we rush to undertake both TMS and DTI in our patients with UCP to obtain as clear a picture as possible of their corticospinal tract reorganisation, we need to consider how this will help. Can we target children to optimal therapy interventions based on their "wiring patterns"? In one study using constraint-induced movement therapy (CIMT), quality of movements improved in both groups but speed of performance only improved in children with preserved crossed projections[2]. In contrast, Islam et al.[3] saw improvements with CIMT, including speed of performance, in children with all forms of corticospinal tract reorganisation, including mixed patterns.

With newer treatment modalities such as non-invasive brain stimulation, the issue of ipsilateral versus contralateral cortical control of the more-affected hand seems even more critical. One might worry that suppressing excitability of the undamaged motor cortex would be unhelpful in patients with only ipsilateral corticospinal projections to the more-affected hand. In a recent study[4] combining CIMT with low-frequency repetitive TMS to depress the excitability of the undamaged motor cortex, children were excluded if they did not have a contralateral motor evoked potential from the affected motor cortex. However, another study with a similar approach was more inclusive[5], with no child showing deterioration in hand function.

The vast majority of children with unilateral CP have had neither TMS nor tractography studies; most have not been in receipt of an intensive evidence-based upper limb therapy program. There is no robust clinical method of assessing corticospinal tract rewiring, although degree of impairment and mirror movements provide some hints. Young children may have more difficulty tolerating either DTI or TMS, but we should surely start therapy from an early age. Perhaps DTI could help us explore

whether we can facilitate, with very early intervention, preservation of the corticospinal tract projection from the affected cortex after early unilateral brain injury in the first place.

References

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